

neutron detector. Thus, the plastic scintillator trigger results in false alarms about 99% of the time. Each trigger causes a 128 microsecond dead time in the primary He-3 neutron system so that the entire system (all He-3 neutron detectors) is dead almost all of the time.

In contrast, the LCV in the present invention involves a different type of coincidence counting than that disclosed in the reference, and it is more accurately called correlation (vs. coincidence) counting and anti-correlation (vs. anti-coincidence) counting. The current invention uses the first neutron from the spallation event itself in the local area of the spallation to gate out subsequent neutrons from the coincidence time interval in just the local area. For correlation counting, the entire detector pulse stream (from the 52 amplifiers) is put into a single data channel and the timing between all of the pulses is analyzed for time groupings or clusters of neutron pulse events. A cluster in a 128 microsecond time interval is counted as a correlated (coincidence) event, where the 128 microsecond is the average neutron lifetime in the primary detector.

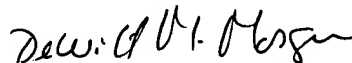
Table I. Differences Between Prior Referenced Anti-coincidence Counting and LCV Anti-correlation Method

Parameter	Prior Anti-coincidence Counting	LCV in Patent Application
Detector type	Plastic scintillator and He-3 detector	Only He-3 detector
Coincidence trigger	Charged particle in plastic	Neutron in He-3 tube
Detected particle for anti-coincidence	Proton or muon	Only neutrons
Veto gated amplifiers	All 52 amplifiers	Only the one amplifier that counted the initial neutron
Dead time for proposed application	Near 100 %	Less than 5 %
Electronics	Both fast plastic detector and thermal-neutron detector	Only thermal-neutron detector
Cost	Two detector systems (Plastic scintillator and He-3 sys.)	One detector (He-3 primary system)

The foregoing differences are set forth in the claims. Claims 1 and 14 have always been restricted to apparatus and method for reducing "interference caused by cosmic ray generated neutrons." By amendment, the way this reduction is achieved by "utilizing localized neutron coincidence vetoes." Claim 1 is further clarified, in subparagraph b), by specifying that the additional pulses vetoed are from the same detector, not from all detectors as required by the reference of record. Similar amendments have been made to claim 14.

In view of the foregoing, it is submitted that this application is in condition for allowance.

Respectfully submitted,



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between the sample and the individual detector modules, the probability of detecting two or more neutrons in the same module is acceptably small (about 10%), so the ability to count the plutonium source neutrons is only reduced by 10-20%.

With reference to Figure 1, detector 11 includes a bottom 13, a top (not shown), three  
5 fixed side sections generally designated 15, and a door section 17. These components define a cavity 19 in which a box 21, or a 200 liter drum 22 (or other suitable container) holding waster material is placed for detection of plutonium and other transuranic materials. (Though both the drum and the box are illustrated, only one or the other would be in cavity 19 at any one time.) While an air gap is illustrated between box 21 and the interior walls of cavity 19, none  
10 is required. Conversely, there is no maximum air gap. The waste container can be made of any material, including steel, wood, plastic, and cardboard. (The material in the waste container may also include steel, plastic, wood and cardboard.) Surrounding the top, bottom 13, and sides 15 is a layer of polyethylene 23. Door 17 is also covered with a layer of polyethylene 25. To remove cosmic ray generated neutrons that are external to detector 11,  
15 layers 23 and 25 are, approximately, 6 inches thick. As indicated by arrow 27, door 17 slides sideways. As they form no part of the present invention, the mechanisms for supporting and opening and closing door 17 are not disclosed.

As is also shown in Figure 1, detector 11 includes a plurality of detector veto pods 31 (or modules), a few of which are illustrated. In the preferred embodiment there are a total of 52  
20 pods, 22 pods are included in sides 15; 10 pods, in door 17; and 10 pods in each of the top and bottom 13. Each pod 31 includes 5 detector tubes 33 embedded in polyethylene casing  
15. For convenience of illustration, each pod is shown as having only 3 tubes 33. As those

skilled in the art will appreciate, the number of tubes per pod and the number of pods can be varied. The greater the number of tubes surrounding a cavity of a given size, the greater the efficiency of the design. However, increasing the number of tubes (whether tubes per pod, or pods) increases the cost of the detector. As those skilled in the art will also appreciate, each tube  
5 33 includes a casing (not shown), an anode wire (also not shown) and is filled with  $^3\text{He}$ . Each anode wire is connected to a source of high voltage, a capacitor and a resistance. As this arrangement is well known in the art it has not been illustrated. As is also well known, the ionization resulting from a thermal neutron colliding with a  $^3\text{He}$  molecule produces a voltage pulse.

10 The LCV circuitry of the present invention is illustrated in Figures 2 and 3. The voltage pulses from each of the 5  $^3\text{He}$  filled tubes 33 of each pod 31 are connected to, for instance, preamp 41<sub>1</sub> which amplifies the voltage pulses and transmits them to the LCV (or veto) circuit 43<sub>1</sub>. In the preferred embodiment AMPTEK model A111 preamps are used. The signal from preamp 41<sub>1</sub> is fed to veto circuit 43<sub>1</sub>. Circuit 43<sub>1</sub> includes: negative input AND gates 45, 47 and  
15 49 and 51; 53 is a logical OR; 55 and 57 are D flip flops used to store signals; and 59 (128 $\mu\text{s}$  One Shot) is a leading edge pulse generator having a 128 $\mu\text{s}$  pulse. Veto circuit 43<sub>1</sub> also includes an enable/veto switch 61. Except for enable/veto switch, veto circuits 43<sub>2</sub>-43<sub>n</sub> (wherein <sub>n</sub> is the total number of pods) are identical to veto circuit 43<sub>1</sub>.

20 Figure 2 shows the interconnections between the veto circuits 43<sub>1</sub>-43<sub>n</sub> (where, again, <sub>n</sub> is the total number of pods or modules) for each pod 31<sub>1</sub>-31<sub>n</sub> and the connection between each veto circuit and OR circuit 71, which combines the output of all the veto circuits. The combined output signal from OR circuit 71 goes to a commercial coincidence logic to register